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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication of the
Portable
Air Compressor

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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Lubrication of the Portable Air Compressor

THE NEED for portable air power developed with the extension of good roads programs, arterial highways and building modernization. The ready mobility of the portable air compressor enabled it to fit in ideally with this work.

The portable air compressor is a rugged machine. It is built to operate under all sorts of weather conditions. By reason of the fact that it must operate in far-away places, it cannot be temperamental, so the lubrication system is planned accordingly. Very often the air compressor, the Diesel or gasoline engine drive, and other essential parts are lubricated and maintained in much the same manner as the truck or tractor. Sometimes the operators do not fully appreciate the necessity for positive lubrication and the limitations of mechanical operations. Appreciation of these factors and a working knowledge of compressor and internal combustion engine lubrication requirements is most helpful in reducing operating costs.

THE portable compressor is intriguing to the "sidewalk superintendent" as he watches the excavation activities around new building construction, highway operations or railway track maintenance. The contractor regards it as far more than a novelty, however. It is the "breath of life" in his work. It must keep operating for if it stops all his air-powered tools also stop. Good maintenance procedure is good insurance against unexpected shutdowns. Good lubrication procedure assures against unwarranted repair.

THE MACHINERY REQUIRED

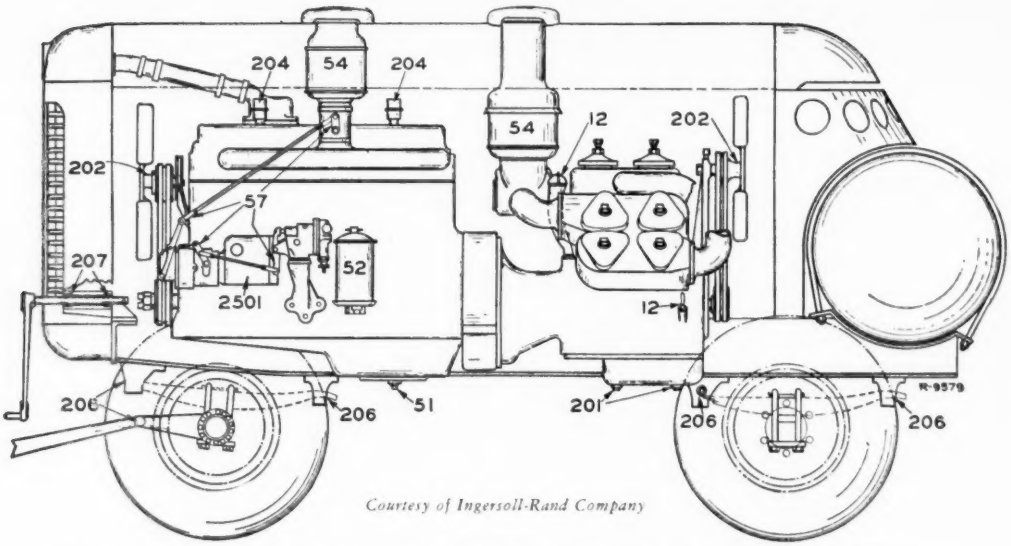
The basic machinery in a portable unit involves the air compressor which may be air-cooled or water-cooled, and the power plant which is a gasoline, Diesel or oil engine.

The portable compressor is unique as compared with conventional stationary designs. The builders have built a lot of air power into a very compact unit; certain types are constructed with their cylinders in a straight line, others, due to space limitations, include the principles of radial design, using either a "V" arrangement or locating both the high and low pressure cylinders in the same plane but at different angles to form a "W". In this design the vertical cylinder is the high pressure element. It is flanked on both sides by the low pressure cylinders.

COOLING

Portable compressors are cooled according to the service for which they are intended and the design involved. Cooling is necessary because when air is compressed, heat is generated. Air cooling relieves the designing engineer of piping and cylinder jacketing details and eliminates the possibility of "freeze-ups" in cold localities if a sudden cold wave catches the operator without anti-freeze. On the other hand, air-cooling requires an arrangement of cooling fins around the cylinders for heat radiation.

Both methods of cooling have the same objective, to control the cylinder wall temperatures so that abnormal over-heating will be prevented in



Courtesy of Ingersoll-Rand Company

Figure 1—Lubrication points (traffic side) on a four-wheel mounted, portable 2-stage, air-cooled compressor.

Service once a day or every 8 hours operation.
12—Compressor crankcase oil level gauge and filler.

Service once a week or every 50 hours operation.
51—Engine crankcase oil drain.
52—Lubricating oil filter.
54—Engine and compressor air intake filters.
57—Governor linkage.

Service monthly or every 200 hours.
201—Compressor crankcase oil drain.
202—Engine and compressor fans.
204—Engine crankcase and rocker arm breathers.
206—Spring shackles and steering gear.
207—Crank handle shaft bearings.

Service once a year or every 2500 hours operation.
2501—Magneto.

See builders instructions for more complete service and lubrication procedure.

the interest of protecting the lubricating film and reducing power required for compression.

Where cooling is properly maintained conventional air compressor oils are used. Where the engine and compressor are built into the one unit, however, engine oil is used throughout.

THE COMPRESSOR

The service to which a portable compressor can be applied is varied. Essentially, it must furnish normal pressure air (up to around 100 pounds pressure) to one, two or perhaps a dozen or more high speed air tools such as

rock drills
concrete breakers
riveting guns
chipping hammers
tampers, etc.

Two stage design predominates, with suitable provision for intercooling of the air.

Service Load May Vary Widely

Quite naturally, the service load will depend upon how the tools are used. When several concrete or paving breakers run off the same air line simultaneously, the compressor may run at full speed and full load. Conversely, tamping might permit it to run at considerably less load.

The service load has a lot to do with lubrication. The oil must be capable of meeting the most severe conditions even though the machine may not impose these conditions at all times. To be sure of this the operator must consider the adaptability of available compressor oils to his particular service and the lubricating systems in the machines he is operating.

Conditions which can affect the performance of an air compressor oil and have a bearing on the selection of the type of oil, involve the temperatures and pressures encountered, the amount of condensation occurring and the metals used.

Temperature

Air enters a portable compressor at around the atmospheric temperature. As the piston rises reducing the cylinder volume the air is compressed. The air temperature at the end of compression depends on the pressure and varies according to Table I. In actual practice, the highest temperatures are reached in 100 pound single-stage machinery. Here the discharge temperature is about 485°, the average temperature of the air in the cylinder is in the neighborhood of 250°, while the oil which is in contact with a cooled cylinder surface is perhaps at 200°. Most portable compressors, however,

TABLE I

Air Compressor Discharge Temperatures

Gauge Pressure	*Approximate Discharge Temperature* Single-Stage	Two-Stage
60#	375°F.	200°F.
80#	430°F.	225°F.
100#	485°F.	245°F.

are of two-stage design and operate at lower temperatures throughout.

The air leaving the discharge valve remains essentially at the temperature corresponding to the discharge pressure. The oil on the discharge valve therefore may be exposed to this temperature for a considerable length of time when the compressor is working hard and not unloading for long periods.

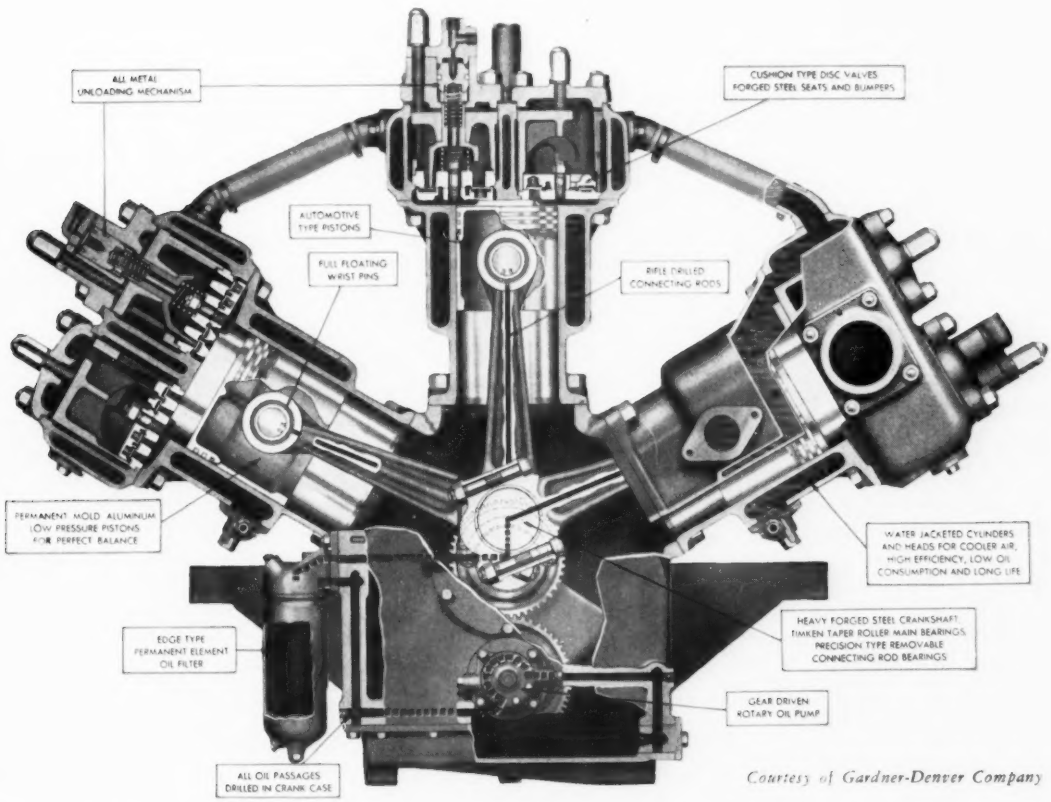
There are several mechanical irregularities which can cause the temperature to go well above the normal discharge temperature such as:

1. Leaking discharge valve permitting hot air to re-enter the cylinders to mix with the intake air, and cause a corresponding increase in discharge temperature.
2. Failure of cooling system.
3. Build-up of carbon restriction in discharge line necessitating an increase in cylinder discharge pressure to deliver the desired receiver pressure.
4. Defective intercooler, causing one stage to do most of the compression.

Low atmospheric temperatures are sometimes encountered in operation of portable air compressors, however, since the compressor is connected to the engine through a clutch, the engine may be started independently. The cold starting characteristics of air compressor oil are not too important, especially since the compressor can be run completely unloaded until the oil is flowing freely.

Pressure

Most portable air compressors are built for pressures between 60 and 100 pounds — for it is in this pressure range that most pneumatic machinery operates. The maximum pressure behind the top


ALL METAL UNLOADING MECHANISM
CUSHION TYPE DISC VALVES FORGED STEEL SEATS AND BUMPERS
AUTOMOTIVE TYPE PISTONS
FULL FLOATING WRIST PINS
RIFLE DRILLED CONNECTING RODS
PERMANENT MOLD ALUMINUM LOW PRESSURE PISTONS FOR PERFECT BALANCE
WATER JACKETED CYLINDERS AND HEADS FOR COOLER AIR, HIGH EFFICIENCY, LOW OIL CONSUMPTION AND LONG LIFE
EDGE TYPE PERMANENT ELEMENT OIL FILTER
HEAVY FORGED STEEL CRANKSHAFT, TIMKEN TAPER ROLLER MAIN BEARINGS, PRECISION TYPE REMOVABLE CONNECTING ROD BEARINGS
GEAR DRIVEN ROTARY OIL PUMP
ALL OIL PASSAGES DRILLED IN CRANK CASE

Courtesy of Gardner-Denver Company

Figure 2—Sectional view of a Gardner-Denver two-stage water-cooled portable air compressor unit. Note features of the pressure lubricating system.

TABLE II

	Straight Mineral		*Rust and*		*Heavy*
	Paraffine Base	*Naphthenic Base*	*Oxidation Inhibited*	*Compounded*	*Duty Detergent*
Gravity	28	20	20	20	28
Flash	440	370	370	375	435
Fire	500	420	420	420	485
Viscosity @ 100	290	330	330	310	300
@ 130	140	140	140	130	140
@ 210	52	47	47	47	51
Viscosity Index	100	0	0	10	85
Pour Point	0	−20	−20	−20	−5
Carbon Residue	.15	.04	.04	.05	.35
Neutralization Number	.03	.03	.03	.08	.85
Saponification No.	.06	.06	.06	6.50	1.60
Ash	None	None	None	None	.25

piston ring will be about equal to the discharge pressure. Maximum bearing pressures will be 4 or 5 times the discharge pressure, but the conditions in a bearing are much more conducive to the formation of a continuous oil film. Thus, it would appear that the pressures which the oil film must withstand in the portable compressor are very moderate. Such will be actually the case in compressors which are perfectly designed, machined and properly operated.

Conditions not infrequently arise within the compressor, however, which result in an uneven distribution of the bearing or ring pressures. This makes it important to use compressor oils of good quality and of the grade recommended, if wear and scuffing are to be kept to the minimum.

Moisture

The ratio of actual moisture content to the moisture capacity of air is the relative humidity. Water condenses from air when the moisture content exceeds the moisture capacity or that is, when the relative humidity reaches 100%. If the temperature of the air is raised, as it usually is, on entering a compressor at the beginning of the suction stroke, then while the moisture content remains the same the potential moisture capacity is increased, consequently, the relative humidity decreases and condensation does not occur. As air is compressed, the relative humidity would increase if there were no increase in temperature. Actually, as air is compressed, the temperature increases and the net combined effect is a rapid decrease in relative humidity with no possibility of condensation during the compression stroke. Normally, then, there is no condensation in a compressor cylinder during operation.

Condensation does occur, however, in an intercooler or after-cooler because here the air remains compressed and the temperature is lowered until the relative humidity passes 100% and the excess moisture is trapped out.

Metals

Among the metals found in air compressor construction are: cast iron, steel, aluminum, copper, bronze and babbitt.

Lubricating Oil Properties

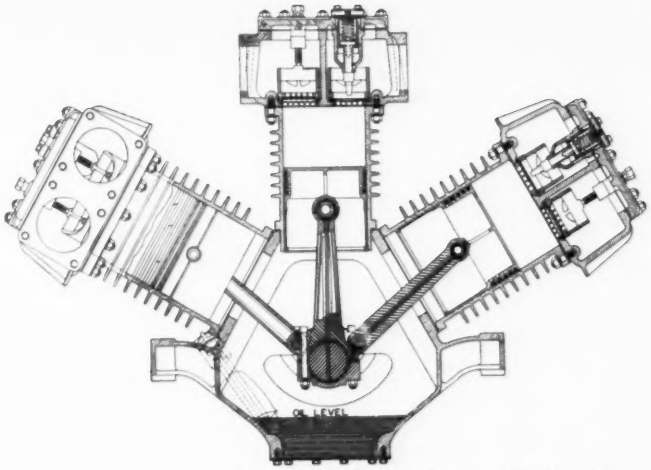
There are five types of oils which deserve consideration in a study of air compressor lubrication: straight naphthenic, straight paraffine, compounded, heavy duty detergent and rust and oxidation inhibited. Identifying tests on typical oils of these classifications are shown in Table II. These types of oils can be identified quite readily. Compared to naphthene, the paraffine oils have higher gravity and flash point. Heavy duty detergent oils have an appreciable ash content from the additives which are used. Oils compounded with a vegetable or animal oil have a comparatively high saponification number. Whether an unknown oil contains a rust and oxidation inhibitor cannot be so readily determined, except that an experimental determination of the anti-rust and oxidation resistance qualities will usually indicate whether or not such additives are present.

Bearing Lubrication

Portable compressor bearings are usually lubricated by force feed or splash although other methods are occasionally employed. In the splash system oil in a reservoir in the crankcase is splashed by a scoop on the end of a connecting rod onto the

bearings and cylinders. The amount of splash can be regulated either by varying the length of the scoop or the oil level. The oil level should be maintained so that the scoop on the connecting rod dips about ¼" into the oil. With the compressor stopped, the oil level should be adjusted to this point and a corresponding mark placed on the oil level indicator. Usually the indicator will already have a mark at about this point previously placed there by the manufacturer.

The oil level should be checked daily and oil added as necessary. Too low an oil level may cause lubrication failure. Too high an oil level may cause foaming or high oil consumption causing a dangerous carbon accumulation at the discharge valve. Many compressors employing the splash system are designed so that the oil level which the connecting rod scoop strikes is automatically maintained constant.



Courtesy of Worthington Pump and Machinery Corp.

Figure 3—Front section assembly of a typical Worthington portable air compressor showing oil level in crankcase and manner of oil distribution.

In some designs the splashed oil is collected in an upper pocket from which it flows to the bearings. The crankcase is well sealed except for a breather or vent pipe which prevents build-up of pressure in the crankcase which would tend to cause oil leakage. Air alternately passes in and out through the breather which should therefore, be equipped with an air cleaner to keep the dust from getting in, and with baffles to keep entrained oil from getting out. Oil must be prevented from leaking where the crankshaft extends through the crankcase. Here an oil slinger is frequently employed taking advantage of the centrifugal force to throw oil off the shaft.

In the force feed system, oil under pressure is forced by an oil pump through passages to the various bearings. The oil drains back to the sump from which it is picked up by the pump and recirculated. When an oil cooler and an oil filter are installed they are usually on the pressure side of the oil pump, fitted with by-pass pipes to prevent stoppage of the oil flow should they become clogged. The system also includes an oil pressure gauge and an oil pressure relief valve, adjusted to maintain the desired pressure.

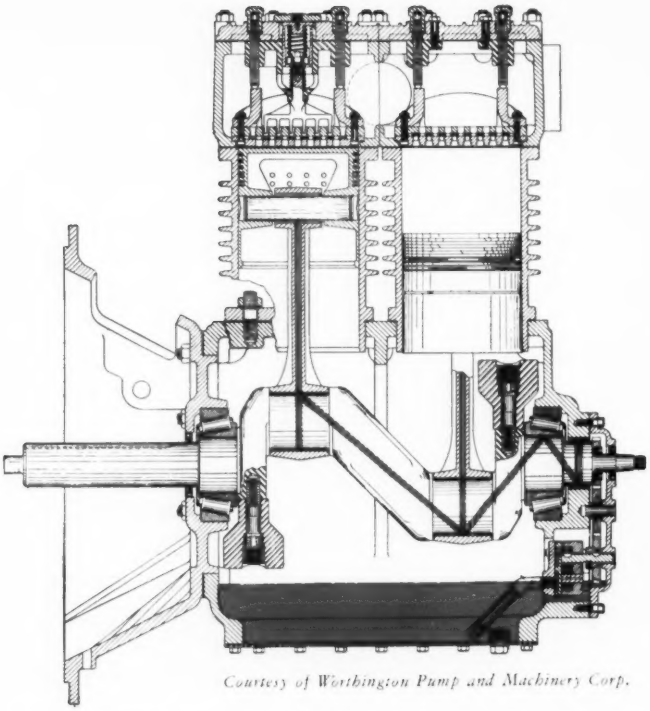
Portable compressor cylinders are lubricated by splash from the crankcase and the cylinder requirements determine the type of oil which should be used in the crankcase. Since most cylinders are lubricated with an oil in the SAE-20 viscosity range the temperature of the crankcase oil should be accommodated to this grade. This means that the oil temperature should be kept under 160°F. to avoid excessive oil consumption.

A large sump increases the life of the oil by keeping the oil temperature down, thus giving it a chance to rest instead of being continuously exposed to the oxidizing conditions in the crankcase.

Cylinder Lubrication

The prime purpose of an oil is to lubricate the bearings and cylinders. Experience has demonstrated that the viscosity of an SAE-20 oil is sufficient to keep the rubbing surfaces separated and piston rings sealed. SAE 10 oils have been used where surfaces are highly polished and tolerance is close, but the 20 grade is better for most units.

The next most important consideration is to use an oil which will not form carbon on discharge valves since carbon is the primary cause of valve difficulties and may lead to a receiver fire. It is carbon that holds discharge valves open causing recompression of hot air and a buildup of the discharge temperature until the kindling point of a dry porous carbon particle is reached. The carbon particle starts glowing, giving off heat which causes other pieces of carbon to smolder. The increasing heat evaporates the oil present in the discharge line and eventually all the carbon accumulated in the inter-cooler or air receiver will start burning. The heat generated causes expansion of air in the system which may escape through the safety valve or rupture the system depending largely on the amount of carbon and oil that has been allowed to accumulate. This is very unlikely to happen in the modern air compressor yet it is a point that must not be disregarded entirely. Valves should be cleaned periodically, receivers, intercoolers and aftercoolers drained regularly and the right type of oil used.



Courtesy of Worthington Pump and Machinery Corp.

Figure 4—Side section assembly of a typical Worthington portable air compressor showing further details of the lubricating system.

Even at the moderately low discharge temperature found in low pressure reciprocating air compressors, any oil remaining as a thin film on the discharge valve will eventually either evaporate or carbonize. A compressor which has been using a heavy paraffine oil which does not evaporate readily will be found to have considerable carbon formation on or adjacent to the discharge valves and a heavy oil film in the discharge passage. On the other hand, a compressor which has been using a light naphthenic oil which evaporates cleanly from hot surfaces will be found to have cleaner valves and drier ports.

This narrows the selection of oil for best normal air compressor service to an SAE 20 naphthenic oil.

The fact that naphthenic oils have low flash points augments rather than detracts from their suitability as air compressor cylinder lubricants. The flash point is a measure of the volatility of an oil and a volatile oil which will evaporate cleanly from hot discharge valves is what is wanted in an air compressor. Volatilization from the cylinder walls is a minor factor, most of the oil reaching the valves by the combination of mechanical and air pressure.

Flash point is determined by application of a test flame to the vapors above the oil surface in a test cup. In an air compressor, where there is no flame it is the auto ignition or kindling temperature rather than the flash point that measures the ignitability of the lubricant inside the air compressor. This point is stressed by leading authorities viz: *"The natural inference of the reader after noting the temperatures of the air at the end of the piston stroke is that he must select an air cylinder oil which has a flash point higher than the maximum temperature apt to be encountered within the air cylinder. As a matter of fact, this is not the case and it need only be carefully noted that the study of air cylinder temperatures is used mainly in testing lubricating oils to determine for resistance against breaking down into carbon etc." It is also of notable interest that the well refined naphthenic base air compressor cylinder oils will have auto-ignition temperatures higher than corresponding paraffinic oils, and well above the air discharge temperatures.

Pressure

The influence of pressure on compressor lubrication is important, because just before metal to metal contact occurs in bearings or piston rings, local high spot pressures of thousands of pounds may exist. Under such critical conditions, the fact that naphthene oils increase more in viscosity at high pressure than paraffine oils makes the naphthene oil preferred for compressor lubrication.

Condensation

A factor influencing the selection of lubricating oil used is the amount of moisture from condensation that may occur. Except where operating conditions are unusual, condensation occurs in an air compressor only in the inter-cooler, after-cooler or distribution system. The formation of rust on these elements has been considered a "necessary evil." If it is desired, however, to minimize this rust formation, an SAE-20 naphthenic rust and oxidation inhibited oil is recommended. Such an oil is also recommended for air compressors which stand idle for long periods in humid climates. The other desirable properties of lubricating oils such as ease of separation from water, freedom from foaming, non-corrosiveness to bearings, stability after long time storage and satisfactory general lubrication must of course be exhibited by these oils which are now not only inhibited against fresh water but also against salt water. This protection from rust is explained by the fact that the inhibitors plate out in minute quantities on interior parts protecting

*From "Compressed Air Data" published by the Compressed Air Magazine.

them from the rusting action of moisture and air. A polished strip of steel immersed in a straight mineral oil, removed and then immersed into distilled water, will corrode and rust very quickly. However, if a similarly polished steel strip be immersed in a suitably inhibited oil, removed and then immersed into distilled water, no corrosion occurs even after many hours at 140° F. Numerous air compressor tests show that suitably inhibited oils give adequate rust protection and at the same time improve the performance of the oil in other respects. They are most resistant to oxidation, foaming, bearing corrosion and wear.

Heavy Duty Oils

Many "heavy duty" oils have many qualities which make them promising two-stage portable compressor lubricants. They are very resistant to oxidation, give protection to bearings of all types. Many have good rust preventive qualities, are good lubricants under wet conditions, have high film strength and keep pistons clean. The "heavy duty" oils are mostly paraffine base; — therefore they are recommended only when specifically approved by the manufacturer for single-stage compressors operating over 60 pounds pressure. At higher discharge temperatures naphthenic oils should be used to insure clean discharge valves.

About the only place a compounded fatty-oil lubricant is needed in portable air compressor service is when cylinder wear is occurring due to carry-over of condensate from the intercooler. Under such conditions compounded oils emulsify with the water to maintain a suitable oil film.

THE ENGINE

As already stated, the modern portable air compressor is driven either by a gasoline or oil engine. The four cycle principle predominates. Some designs are convertible from one fuel to the other by making simple substitution of fuel accessories.

Gasoline Power

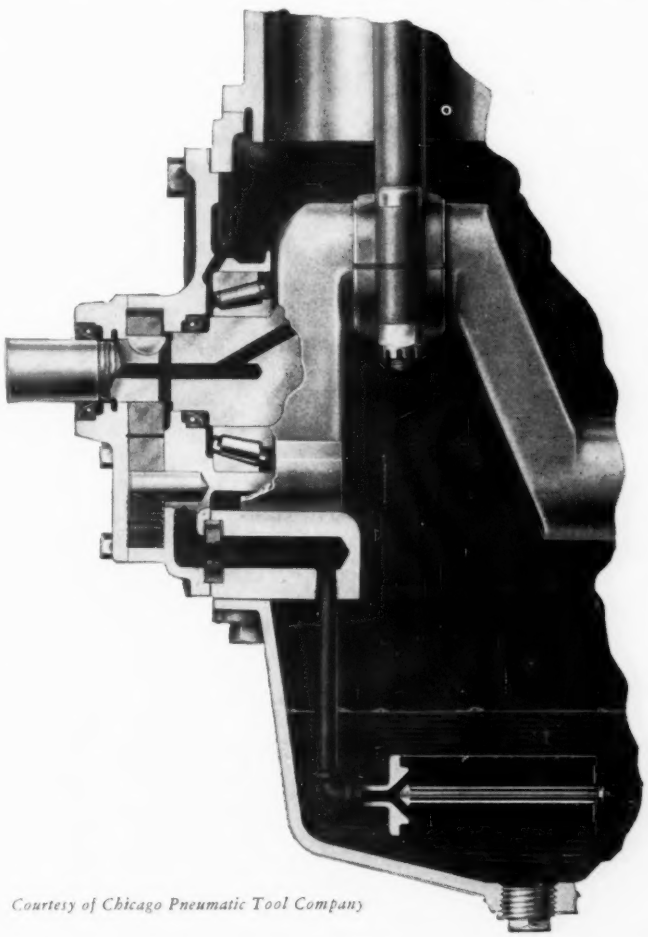
Simplicity of design, and ready access to all parts have been accepted as fundamental requirements by the builders of the gasoline engine for portable compressor service. Particular attention has been given to include completely automatic lubrication, doing away with all complications to assure positive distribution of oil to the various parts.

The selection of lubricating oil for a gasoline engine should be made strictly on the basis of quality, involving chemical characteristics to insure proper refining for removal of impurities, and on the basis of viscosity, to insure the proper grade.

Excessive friction may result from the use of an oil of either too high or too low viscosity. Too high a viscosity will give a good film but the internal friction in the oil may be excessive; conversely, if the viscosity is too low the film may be too thin, allowing excessive wear. The physical characteristic viscosity, therefore, is of importance in the selection of a motor oil, as it is a measure of the ability of the oil to maintain the proper film under the existing conditions of speed, pressure, and temperature.

Protecting Lubrication

Oil filters and air filters are advantageous in reducing engine wear, for they keep road dust out



Courtesy of Chicago Pneumatic Tool Company

Figure 5—Showing bearing and lubrication oil pump details on a Chicago Pneumatic portable air compressor unit.

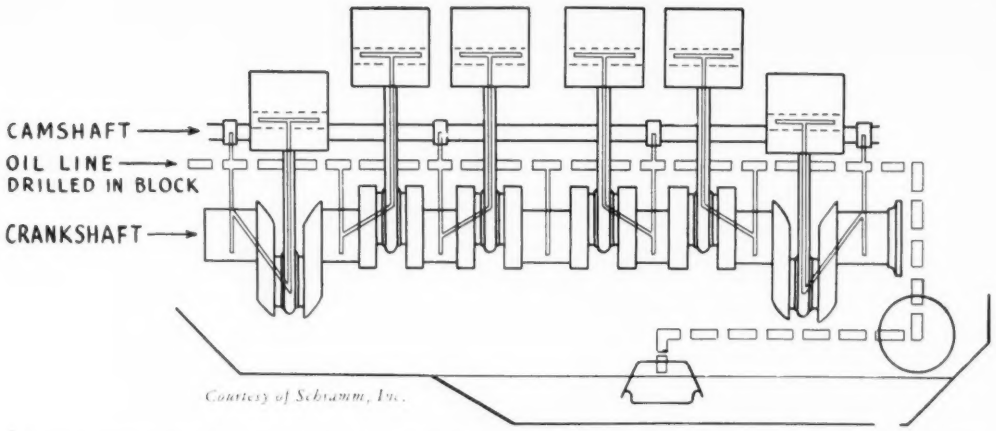


Figure 6—Details of the compressor mechanism in a Schramm portable air-compressor showing oil line with respect to other parts.

of the air and fine abrasives out of the oil.

Pressure circulation is advantageous in that it provides flood lubrication for the bearings to insure that they will not only be washed free from accumulations of foreign matter, but also cooled to a certain extent.

Lubrication is further protected when using a motor oil which is fortified with materials to retard oxidation and give added stability to the oil film.

Oil Gauge Pressure

The oil gauge indicates that engine lubrication is being maintained. It does not, however, indicate the amount of oil being circulated.

Oil gauge pressure and rate of circulation will vary according to the viscosity or relative fluidity of the oil. Oil pressure drop will frequently cause worry to some operators. It is an indication of impaired lubrication, however, only when pressure is lost entirely, for this may mean a broken or inoperative pump.

With the natural reduction in oil viscosity which accompanies normal engine operation, resistance to pumping will be proportionately reduced and flow rate increased. A certain amount of drop in pressure, especially during full load or warm weather operation, should, therefore, not be unexpected.

In other words, the lighter the oil, the more easily will it pump and circulate; this requires less pressure. Reduction in body or viscosity may result from heating or dilution. If the oil pressure drops very low it may indicate that the viscosity of the oil is too low for the operating temperatures involved. Perhaps the oil was too light in the beginning or there has been excessive dilution.

To correct this, check back on the grade of oil used and run with as lean a fuel mixture as practicable. Reduced choking, the least amount of idling, and bringing an engine up to operating temperature as soon as possible after starting will all aid in reducing dilution.

High or rising gauge pressure during operation should be of far more concern, for it may be an indication of faulty lubrication due to clogged oil lines, or the oil being too sluggish and heavy to pump readily and distribute freely to the bearings, or splash to the cylinder walls, according to the type of lubricating system involved.

Carbon Deposits

Just how an excess of lubricating oil may cause abnormal carbon deposits will be of interest. Theoretically, a very small amount of oil is necessary to maintain the requisite lubricating film on the cylinder walls and serve the respective bearings; actually, however, a considerable excess of oil will be used. Where the piston rings give the proper degree of seal and the cylinder walls are not abnormally worn, very little oil should pass into the combustion chamber. If the oil level is carried too high, however, the amount of oil on the cylinder walls may be so excessive that some cannot help being pumped into the combustion chamber. A smoky exhaust may indicate oil pumping.

Carbon in the combined form in petroleum products, is not harmful. It is only a detriment, when, in the form of soot (from incomplete combustion), or deposits of carbonaceous tarry matter (from oxidation of the crankcase oil). This may, of course, have a very decided effect upon the operation of the engine, the amount of power developed and the amount of "knocking," according to the extent to which carbon deposits are formed on the spark plugs, pistons, cylinder heads, around the rings, on valves and valve seats, and in the crankcase.

The amount of ultimate carbonaceous residues, also their nature, will depend entirely upon the degree of heat present, the extent of refinement of

the lubricant, the base of the crude and the effectiveness of the additive in keeping the engine clean through the use of a "heavy-duty" oil.

Diesel or Oil Engine Lubrication

The Diesel or oil engine gives the operator of a portable air compressor an interesting alternative to the gasoline engine.

Oil engines are economical and suitable where starting is accomplished under normal temperatures. If a machine must start at extremely low temperatures, the gasoline engine is preferable.

The term "Diesel or oil engine" as generally used, is applied to internal combustion engines that burn heavy liquid fuels. The distinguishing features of these engines are that the fuel vapor is not mixed with air before it is admitted to the cylinder, and no inflammable mixture of vapor and air is compressed preceding ignition.

Diesel engines compress air alone; the heat of compression is used to ignite the atomized liquid fuel which burns by consuming the oxygen of the air in the cylinder, the engine transforming the heat energy into work. To facilitate and accelerate the burning of a liquid fuel, it must be vaporized and intimately mixed with air immediately preceding its ignition. Both the Diesel and oil engine as designed for portable compressor service, are capable of burning practically any grade of liquid fuel from kerosene upward.

Lubrication Must Be Positive

The severe service conditions prevailing in the lubricating system of any such engine requires an oil of maximum stability. Inferior or unsuitable lubricating oils can cause gummy deposits which are not detected until they have formed to excess. Meanwhile, the oil may still appear to be in fairly good physical condition.

Gummy deposits are most dangerous when they lodge within the oil pipes leading to the bearings, or the oil ducts within the crankshaft or the connecting rods. The accumulation of such deposits may not be observed until sudden restriction or stoppage of oil to some bearing or group of bearings occurs, with resultant burned out bearings and the necessity for costly repairs.

Power Cylinder Lubrication

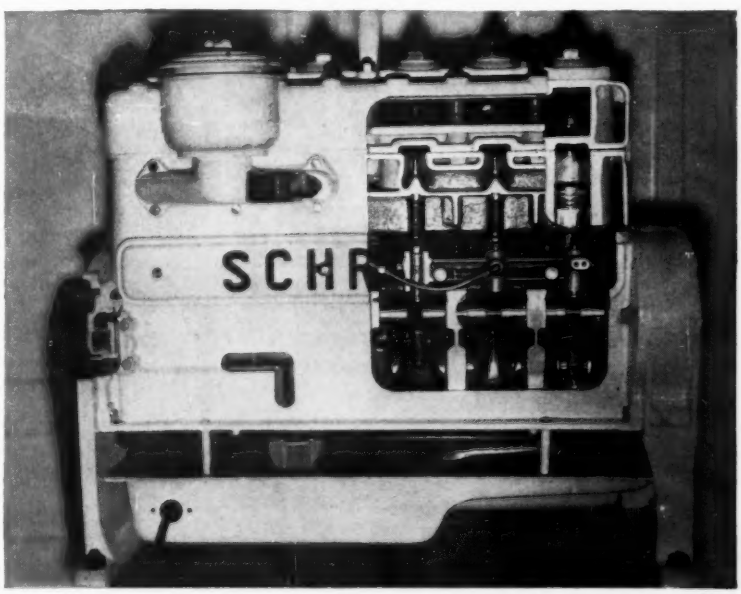
Efficient lubrication of the power cylinders requires continual maintenance of an oil film on the cylinder walls to afford adequate protection regardless of the grade of fuel, the completeness of combustion, the piston ring pressure, and the operating temperature. Successful engine cylinder lubrication is dependent on three factors; i.e.,

1. The use of properly refined oil.
2. Application of sufficient, though never excessive, amounts, and
3. Delivery through oil-ways so located that the piston and rings and bearings will receive an ample supply.

To secure the most effective lubrication of engine cylinders, the oil should be delivered continually to the cylinders and pistons by some form of automatic lubrication, which will insure a charge of sufficient volume to cover the entire cylinder wall under the swabbing action of the piston.

Good Piston and Oil Film Seal Important

The high pressure gases above the pistons of any such engine are prevented from leaking between the piston and cylinder walls by properly fitted rings in conjunction with a suitable sealing medium in the form of a lubricating film. Although the metal surfaces of cylinders, pistons, and rings are carefully finished and accurately fitted, leakage of gases cannot be prevented unless the small clear-



Courtesy of Schramm, Inc.

Figure 7—Cut-away side view of a Schramm portable air compressor unit showing relative location of working mechanisms.

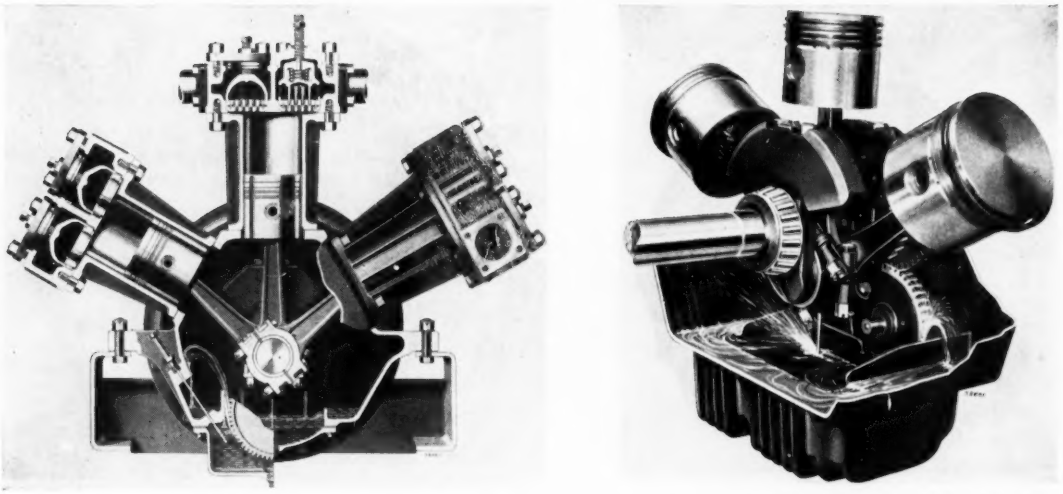


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Figure 8—Details of the I-R unified power plant for two-stage air-cooled compressors. At the left is shown part of the constant level oiling system along with cylinder and piston arrangement. At the right the piston and crankcase assembly view shows more of the oiling system, the air-cooled oil reservoir and the cushioned arrangement of Timken bearings.

ances between the wall and rings are sealed effectively by the lubricant.

The lubricating oil film must be maintained under two concurrent conditions of operation; i.e., high temperature and high pressure. The higher the temperature of the products of combustion, the hotter will be the adjacent parts, with consequent reduction in the body of the oil film separating the metal surfaces. The greater the gas pressure, the more difficult it is to maintain a lubricating film between the rubbing surfaces. Proper functioning of the upper piston rings is particularly important under these conditions.

The highest pressure is found behind the uppermost ring and is nearly as great as that on the piston head itself; it decreases gradually behind each succeeding ring until it is practically negligible behind the lowest ring. These pressures along with the natural spring of the rings will force them against the cylinder wall, producing a squeezing action which the lubricating oil must support.

Combined Effect of Temperature and Pressure

The high temperature of combustion in an engine cylinder occurs simultaneously with the high pressure. This combined action, especially under adverse conditions, will be very detrimental to the oil film which if inadequate will thin down to cause loss of compression and excessive cylinder liner wear. This inevitably results in increased cost of power and upkeep.

Under such conditions of high pressure and temperature, the lubricant must be able to spread rapidly on the cylinder walls and to replenish its own lubricating film. It must have film strength even when exposed to high combustion temperatures as well as the pressures to which it is subjected through the piston rings, and it must maintain a complete piston seal effectively under all conditions. Cylinder liner wear is generally greatest at the combustion end of the cylinder, in the vicinity of the upper piston ring, where maximum temperatures and pressures exist. The wear decreases along the cylinder walls in proportion to the lower temperatures and pressures encountered during the power stroke.

Bearing Wear

Excessive bearing wear may be as serious as excessive cylinder wear. It is impossible for metal surfaces under pressure, such as journals and bearings, to move in actual contact even for short periods of time without generating heat. This will quickly become excessive and eventually will injure the materials unless the surfaces are positively separated by a film of oil which lubricates as well as cools the bearings.

While cylinder wear, in extreme cases, leads to loss in compression and consequent loss of power, excessive wear of main bearings, in addition to causing loss of power may also lead to fracture of the crankshaft. In the four-cycle engine, comparatively slight wear may be indicated by pounding, especially if this wear has occurred in the wrist pin bearings.

Amount of Lubrication Required

The quantity of oil which should be circulated through a bearing lubricating system varies widely, according to engine design and the means of

lubrication. It is largely dependent upon the size and speed of the unit as well as the design of the lubricating system. The chief requirement is that the amount of oil circulated shall be considerably in excess of what is actually necessary for lubrication, to enable the volume of oil flowing through the bearings to serve as a cooling medium in addition to maintaining a film between the bearing surfaces. Properly refined oils of suitable viscosity (according to the operating conditions) carry the prevailing pressures, and also cool effectually.

Selection of the Lubricating Oil

The engine manufacturer will usually designate the type and grade of oil to be used in his engine. Best performance results from the use of high quality oils in which additives are used to impart properties which give a clean powerful engine requiring a minimum of maintenance. A brief description of such oil properties follows.

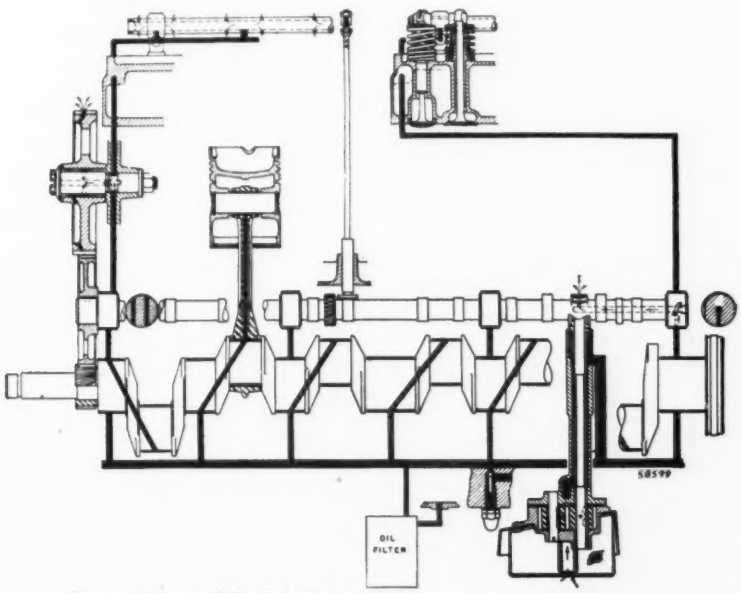
HEAVY-DUTY DETERGENT TYPE ENGINE OILS

The heavy duty detergent type oil is well suited for either gasoline or Diesel engine lubrication. The meaning of the term detergency and particularly its application to engine lubricating oils is of interest. The dictionary defines the action of detergency as the cleansing or purging away of foul or offending matter. This is exactly what the chemical compound added to the straight mineral base oil does to prevent the piston rings from sticking in their grooves. In new or clean engines, the initial deposition of products of fuel combustion and oil decomposition is prevented. In used engines, detergency exerts a cleansing or dissolving action on old, previously formed deposits, preventing their redeposition.

During the combustion fuel deposits are formed consisting of gummy residues and soot. In addition, decomposition of the lubricating oil reaching the rings is also influenced by this combustion process. These gummy residues act as binders for the fuel soot and build up sticky deposits on the ring lands and in the ring grooves.

The additive in the lubricating oil enables the oil reaching these engine parts to take up the deposits. This is accomplished partially by dissolving them but mostly by dispersing them in a finely divided state. This washing action of the lubricating oil in these potential deposit-forming bodies from fuel combustion is exerted as soon as the particles reach the oil. This same action occurs in other parts of the engine reached by combustion chamber products when blow-by occurs past the piston rings. These deposit-forming materials are partly dissolved and partly dispersed in suspended state throughout the lubricating oil and thus are able to be carried out of the engine when the oil is drained. Thus the engine is kept clean by this detergent action of the lubricating oil.

Another characteristic of detergency in engine



Courtesy of Ingersoll-Rand Company

Figure 9—Schematic diagram of pressure oiling system for I-R engines adaptable to portable air compressor service.

lubricating oils is the ability to remove previously formed deposits from the surfaces of engine parts. This action is likened to that exerted by soap and water in cleansing dirty surfaces. These removed deposits are then broken up and dispersed in a finely divided state throughout the body of the oil for removal from the engine at the oil drain period.

Oxidation Resistance

As improvements in engine design were made, permitting the development of more power for the same size and weight, new materials were necessary to withstand the higher stresses imposed. Chief among these was the copper-lead bearing which could stand heavier loads and higher temperatures than the ordinary babbitt bearing. With the rapid adoption of this bearing for heavy duty service in both gasoline and Diesel engines, it was discovered that under these more severe operating conditions ordinary motor oils were corrosive to this copper-lead mixture. This corrosiveness was brought about by the inability of this type of oil to resist oxidation which results primarily from the action of heat and atmosphere. The resultant acidic bodies formed by this oxidation process attacked the lead in the copper-lead mixture taking it into solution and leaving a porous copper structure which crumbled and broke away. Thus it became necessary to impart oxidation-resisting properties to the oil.

Improvement in oxidation resistance of the straight mineral type engine oil, as determined by corrosiveness to the alloy type bearing, was attained by the use of chemical compounds or additives. These compounds were designated as oxidation inhibitors or corrosion inhibitors.

The corrosion inhibitors primarily afford a protection to the alloy type bearing so as to minimize the effect of acidic bodies on these bearings.

The oxidation inhibitors provide protection to this type of bearing by combatting the formation of acidic bodies; this also results in a minimizing of varnish and lacquer deposits on piston skirts.

Dispersion

During this development of oxidation-resistant heavy-duty engine oils dispersion was also improved.

Dispersion in a lubricating oil is a physical reaction in that the products of fuel combustion, chiefly soot, along with some oil decomposition products are held in suspension. This appears to be accomplished by the dispersing of these contaminating particles in a finely divided state throughout the body of the oil. By this action agglomeration of the particles is prevented and oil filters do not clog and strainers stay clean.

Although the phenomenon of detergency employs dispersion to a large extent, the two properties should be considered separately. This is readily appreciated when one considers that while all detergent oils known today have good dispersive properties, not all oils with high dispersion values display satisfactory detergency.

CONCLUSION

Just as with all other equipment, the careful attention given to the selection and application of good quality lubricants in the correct viscosity grades is the best insurance for low operating and maintenance costs. The wise operator will do well to avail himself of the benefits which result from the use of suitable additives in lubricants for both the compressor and the engine of portable air compressors.

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